Fertilization with Easily Soluble Phosphorus Decreases VA-Mycorrhiza in Soil

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Introduction

Vesicular-arbuscular mycorrhizae (VAM) are fungae that form symbiosis with higher plants. The symbiotic interactions favour plant uptake of mineral nutrients, particularly phosphorus and especially on soils with a low P status.

The reducing effect of high content of easily available phosphorus in soil on the amount of VA-mycorrhiza is well-known. We also know, that in soils with a low easily available phosphorus content the significance of VAM for plant growth and uptake of phosphorus is strong. In the present investigation the amounts of VAM are investigated at two long-term experimental sites where a wide range of plant available soil phosphorus was established a long time ago. This means that the influence of climate and soil characteristics on the presence of VAM is diminished.

Experimental

The impact of the use of easily soluble P fertilizers on the presence of VAM in soil was studied in two Swedish long-term P field experiments (Ultuna and Offer).

The experiments were run for 28 years (1963-1990). Monocalcium-dihydrogenphosphate, $Ca(H_2PO_4)$ was used as P source and the annual fertilizer rates varied greatly (0, 5, 15 and 45 kg P ha^{-1}). N and K were added in suitable amounts.

Soil cores were sampled six times at even intervals during the period and the presence of VA-mycorrhiza was determined by counting the number of diaspores.

Geographic data and soil characteristics of the experimental sites are shown in Table 1.

Table 1
Geographic data and soil characteristics of the experimental sites

Site	Location	Altitude, m	Annual mean temperature, °C	Clay %	Silt %	Sand %	pH (H_2O)
Ultuna	60°N 17°E	10	5.5	55	44	1	6.3
Offer	63°N 17°E	30	2.5	35	63	2	5.5

Results

Additions of 45 P ha^{-1} $year^{-1}$ rapidly decreased the number of diaspores. Five years after the start of the field experiments the diaspore frequence was reduced from 16 to 8 at Ultuna and from 29 to 2 at Offer (Fig. 1A, 1B). The spore frequence then stabilized, fluctuating between 2 and 16. The mean value for the whole period was 8.5 (Table 2).

More moderate P dressings had only minor effects. Fertilizing with 5 or 15 P ha^{-1} $year^{-1}$ did not seriously affect the spore frequence. At these P rates the spore number was about constant and the periodical mean did not differ between the two treatments (Table 2).

Excluding P fertilization doubled the number of VAM diaspores. In the non-phosphorus treatment the number of diaspores doubled within five years at Ultuna and within 14 years at Offer (Fig. 1A, 1B). Further on, in 27 years, the spore frequence increased three times at Ultuna and twice at Offer.

Table 2
Impact of annual phosphorus fertilization on easily soluble P and number of VAM diaspores in soil and annual P yield

Annual P fertilization, kg P ha^{-1}	Easily available AL-P, mg P 100 g soil	VAM diaspore number, 25 g $soil^{-1}$	Mean annual P yield, kg P ha^{-1}	n
0	2.1a	45.8a	10.8a	12
5	2.4a	28.9b	11.7a	11
15	3.2b	25.6b	13.3b	12
45	7.0c	8.5c	14.2b	12

Remarks: Means of six samplings at Ultuna and Offer performed at even intervals, 1963-1990. Figures with different letters within the columns are significantly different at $P < 0.05$

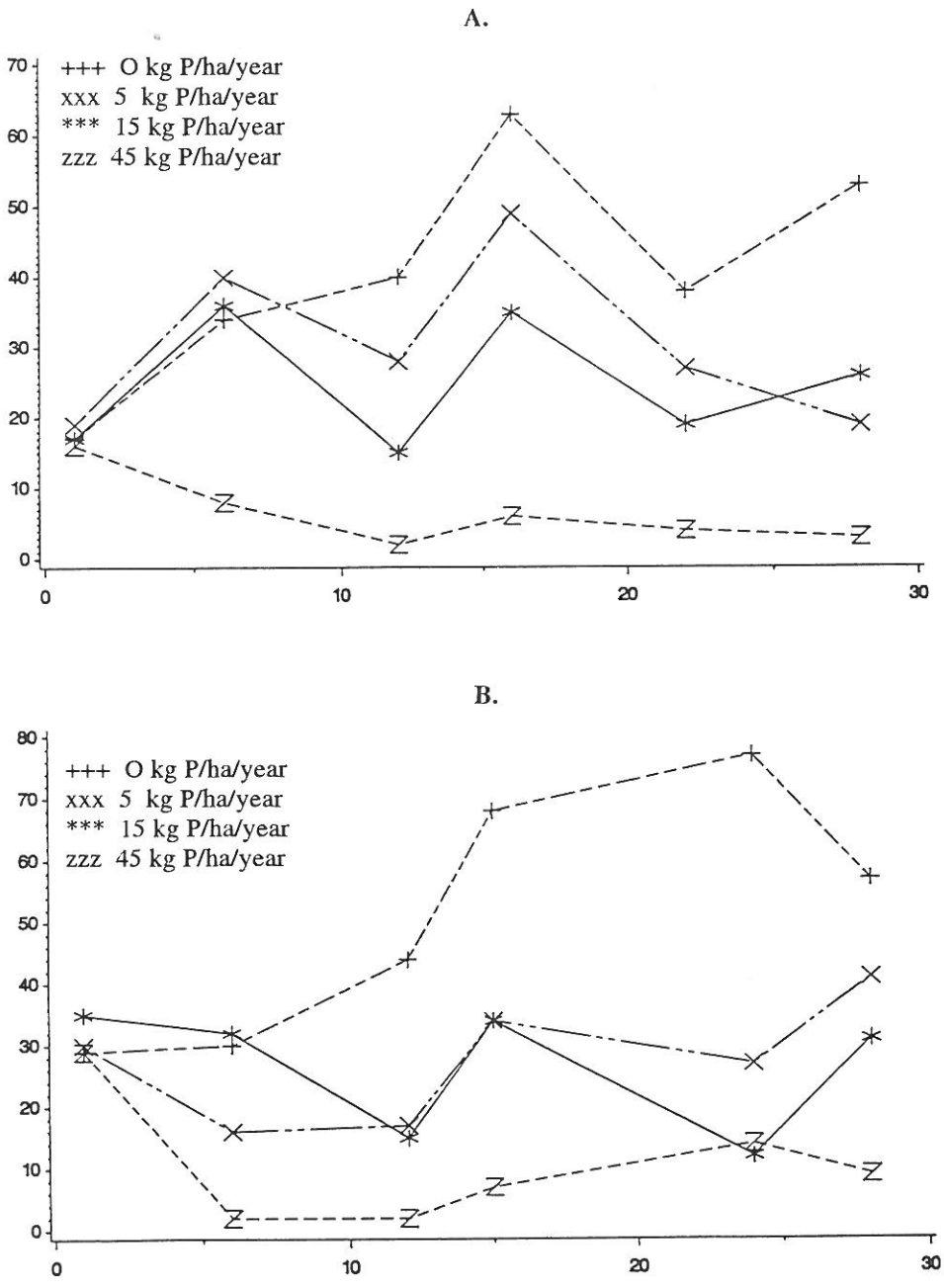

Fig. 1

Relation between the number of VAM diaspores and duration of field experiment at Ultuna (A) and Offer (B). Four P fertilizer rates. Vertical axis: Number of VAM diaspores in 25 g air-dry soil. Horizontal axis: Duration of experiment, year

There was a negative connection between soil P and VAM diaspores.

The amount of VAM diaspores in soil was negatively correlated with P fertilization level and amount of easily available soil P (AL-P) (Table 3), which was what we expected.

Table 3

Pearson correlation coefficients between P fertilization levels, easily available soil P, amount of VAM diaspores and P yield

	P fertilization level	Easily available AL-P	Amount of VAM spores	P yield
P fertilization	-	0.843***	-0.699***	0.235
AL-P		-	-0.697***	0.357**
VAM			-	-0.209
P yield				-

** P (0.01) ; *** P (0.001) ; Number of observations = 48

A positive correlation was found between P yield and AL-P (P = 0,01). However, the correlation coefficient was quite small, indicating that other factors besides soil content of easily available P greatly influenced P yield.

There was not any significant correlation between P yield and the amount of VAM diaspores.

Changes in spore frequence are temperature dependent.

Offer is situated more northern than Ultuna and at a higher altitude, with a lower annual mean temperature (Table 1). This also influences soil temperature. We assign the fact that it dared much longer time at Offer than at Ultuna to double the spore frequence in the zero P treatment to be an effect of the lower temperature regime at Offer.